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Artikel: Underwater concrete bridge (Norway)

Autor: Einstabland, T. / Olsen, T.O.

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1. Underwater Concrete Bridge (Norway)

Operator:	*Statoil*
Contractor:	*Ing. F. Selmer A/S (turnkey responsibility)*
Concrete design:	*Dr. techn. Olav Olsen*
Concrete mix design and quality control:	*Noteby*
Model tests:	*The River and Harbour Laboratory*
Environmental loads and response:	*Det norske Veritas*
Design review and control:	*Dr. Ing. A. Aas-Jakobsen A/S*
Number of bridge elements:	*5*
Total length of bridge:	*590 m*
Duration of design, construction and installation:	*9 months*
Service date:	*1983*

Introduction

Gas is transported in pipelines from the Statfjord Field in the North Sea, to a treatment plant at Karmøy, on the west coast of Norway. Statoil owns the majority and operates the Statpipe Development Project.

A particularly difficult portion of the 850 km of gas lines is where they approach the shore. At this location the topography is rocky, and the environmental conditions are very rough.

Traditional alternatives for pipe protection in such exposed areas are blasting on a seabed trench or driving a subterranean tunnel. Due to limited time available, however, these solutions were not suitable, and the contractor won the project with their own proposal of an immersed concrete tube concept. The contractor provided the idea, design and construction, assuming turnkey responsibility.

The project was successfully completed within 9 months from contract award in February of 1982. The gas lines were installed in the spring of 1983, as planned.

Description of the Concept

Two gas lines are placed inside the underwater concrete bridge, Fig. 1.

The submerged concrete tunnel has a length of 590 m starting at a water depth of 30 m and ending up at waterlevel. The tunnel consists of 5 elements ranging from 90 m to 150 m in length. The cross-sectional area varies from 30 to 45 m^2, the biggest element has a displacement of 7000 tons. The tunnel elements rest on 6 heavy foundations, the lower part of which were casted under water.

The 5 tunnel elements were casted in dry dock away from the site, simultaneously with the construction of the foundations.

The tunnel elements were towed to the site, water-ballasted and pulled down to the foundations, and then flooded. After securing the elements to the foundations with lateral supports, the pull-in of the pipelines could be performed. In this way this concept provided a smooth access for the pipeline and a permanent protection in this rocky shore area.

Design

Three of the elements are simply supported at the ends, and the remaining two have overhanging portions.

Dominating loads are deadweight, prestressing and waveforces. The design wave with return period of 100 years is:

Waveheight:	18.5 m
Period:	14 s
Wavelength:	230 m

Sufficient prestress is provided to avoid membrane tension for a waveloading of 60 % of the 100 year design wave. This to avoid water pumping in cracks, and to assure durability.

Silica and plasticizers were added to the mix, to ensure high quality and good workability. Obtained strength (C75) was well in excess of that specified.

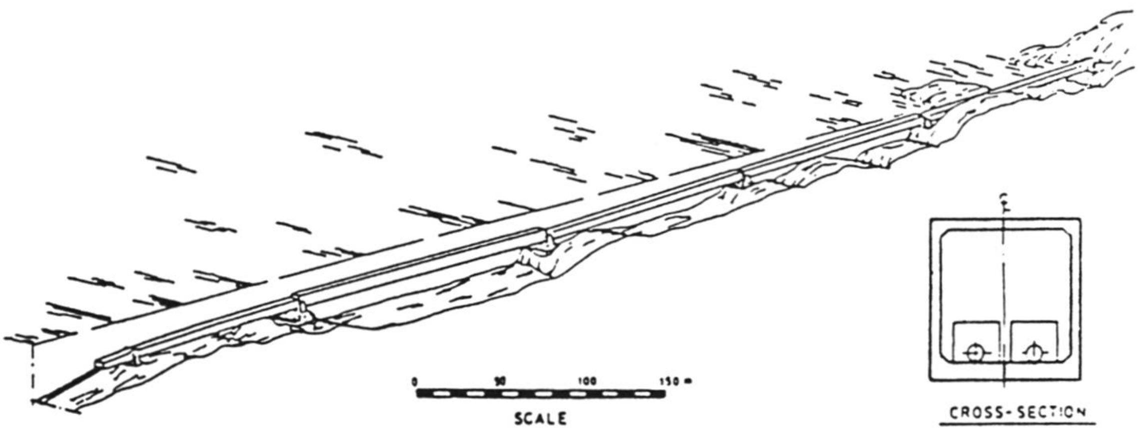

Fig. 1

The foundations, which are placed on blasted rock, consist of a lower part casted in-situ and an upper prefabricated part weighing 400 tons. The vertical and horizontal loadings from the elements are transmitted through the foundations to the rock without taking any anchor rock bolt into account.

High strength concrete

It is obvious that high strength concrete is very important for deepwater platforms for say 300 m water-depth. High strength concrete is, however, also very important for this type of structure even with a watedepth of 30 m. This is due to the large environmental loadings in this area. The loadings depend on the size and volume of the structure. The design value used for the elements were C65, except for element no. 1 and no. 2 (element near shore) where C60 was used.

At this time, in 1982, C65 was the maximum concrete quality tabulated in Norwegian codes. The beneficial influence of even higher concrete strength is clearly demonstrated in Fig. 2. Using a concrete quality of C100 instead of C65 will dramatically reduce the concrete volume, the reinforcement and the prestressing cables. A concrete strength less than say C50 will lead to significant increases in the structure size and in the quantities.

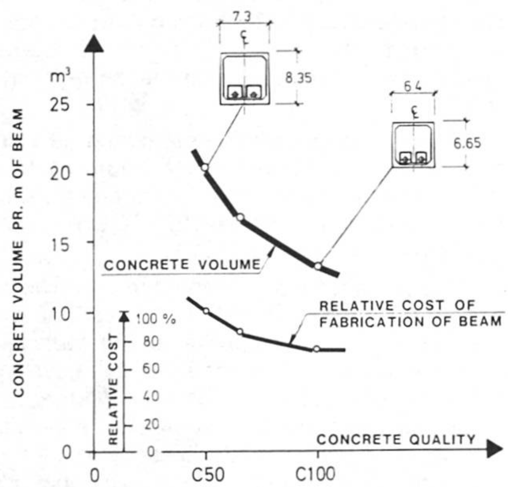

Fig. 2

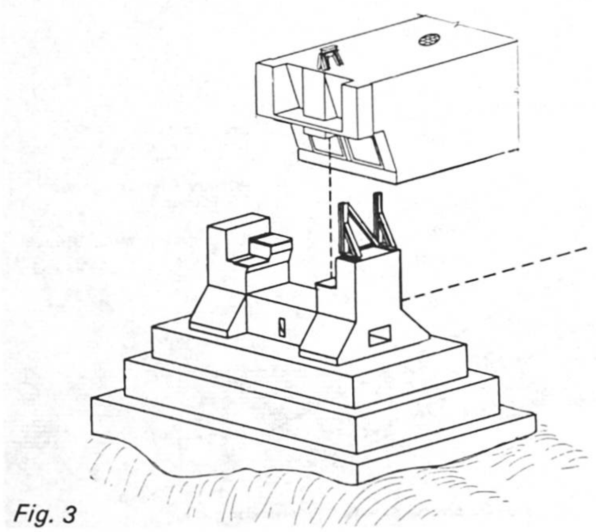

Fig. 3

Construction

The underwater work at Kalstø were executed from two flat-top barges moored on the site. The underwater work was performed with divers using Nitrox gas. Nitrox is a mixture of nitrogen and oxygen. Compared to air this mixture enables the diver to stay longer under water.

Since the weather played such an important role in this project, a system was built up for continously and accurate monitoring of environmental conditions like waves and wind, also allowing reliable forecasts to be made. The waves were measured every 15 minutes. Highest recorded waveheight during the construction period was 11 m.

The foundation and the elements were constructed simultaneously and a high degree of accuracy was imperative. A special survey technique developed for this project made the foundation to be performed within an accuracy of 10 cm.

The foundation tops were installed by the contractors floating crane, Conlift. The tunnel elements were ballasted to a positive buoyancy of about 60 tons and pulled down to the foundations, Fig. 3.

The elements were all installed within an accuracy of a few cm.

(T. Einstabland, T. O. Olsen)